

## New and Newly Recorded Oribatid Mites (Arachnida, Acari, Oribatida) from the Ryukyu Islands, Japan

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**Abstract** Thirteen new species of oribatid mites are described from the Ryukyu Islands of Japan. They are: *Lohmannia unsui* sp. nov., *Sadocepheus yakuensis* sp. nov., *Mycobates tricostatus* sp. nov., *Birobates nasutus* sp. nov. from Yaku Island, *Mochlozetes ryukyuensis* sp. nov. from Kuchinoshima, Akuseki and Ishigaki Islands, *Dolicheremaeus magnus* sp. nov., *Fissicepheus gracilis* sp. nov., *Astrocarabodes bituberculatus* sp. nov. from Okinawa Island, *Fissicepheus defectus* sp. nov. from Okinawa and Tokashiki Islands, *Astrocarabodes obscurus* sp. nov. from Tonaki Island, *Hoplodthiracarus insularis* sp. nov. from Tokashiki Island, *Defectamerus insularis* sp. nov. from Zamami Island, and *Heteroppia setigera* sp. nov. from Ishigaki Island. Seven species are newly recorded from Japan. They are: *Trhypochthonius javanus* Csiszár, 1961 and *Lamellobates orientalis* Csiszár, 1961 known from Java, *Neoliodes bataviensis* Sellnick, 1925 known from Java and Australia, *Dolicheremaeus orientalis* Aoki, 1965 known from Thailand, *Camisia invenusta* (Michael, 1888) known from Europe, *Neoliodes striatus* (Warburton, 1912) known from Africa, and *Eremaeozetes undulatus* Mahunka, 1985 known from the Antilles Islands.

**Key words:** Oribatida, new species, Ryukyu Islands, Japan.

The Ryukyu Islands are thought to be an extremely interesting area by many biologists because of its rich flora and fauna representing a subtropical biodiversity. Their oribatid fauna was also expected to be rich and not a few investigations were done in the Ohsumi Islands, the Tokara Islands, the Amami Islands, the Okinawa Islands, the Kerama Islands, the Miyako Islands, and the Yaeyama Islands, which constitute the Ryukyu Islands (Aoki, 1973, 1976, 1982, 1984, 1987a, 1987b, Ito & Aoki, 1999, Karasawa & Aoki, 2005, Nakatamari, 1978, 1980, 1982, 1983, etc.). Although the results of these investigations gave proof for a very rich oribatid fauna there, a number of species are remaining unnamed and waiting for description.

The present paper aims at describing a part of these unnamed oribatid mites from the Ryukyu Islands. All the specimens of the type series are deposited in the collection of the Department of Zoology, National Science Museum, Tokyo.

### *Lohmannia unsui* sp. nov.

(Figs. 1–7)

**Measurement.** Body length 1015–1020  $\mu\text{m}$ , width 500–550  $\mu\text{m}$ .

Prodorsum. Rostrum smoothly rounded (Fig. 1). Rostral setae weakly broadened, with spines on both sides, sharply pointed at tip, 2.2 times as long as their mutual distance (Fig. 3). Lamellar setae a little thinner and longer than rostral setae, with spines on both sides (Fig. 2), 1.38 times as long as their mutual distance. Interlamellar setae as thick as and a little longer than lamellar setae; their length and their mutual distance almost equal. Sensillus weakly sigmoid, with 6–7 long branches and a short branch near the tip (Fig. 7). Anterior exobothridial seta (*exa*) curved near the base, directed forward, weakly thickened, beset with small spines in two rows (Figs. 4–5). Posterior exobothridial seta (*exp*) slender leaf-shaped, with spines on both sides (Fig. 6). An irregularly rounded porose area found between rostral setae and one behind lamellar seta on each side; a

transverse porose area between interlamellar setae.

**Notogaster.** Notogaster gently swollen on both sides. Sixteen pairs of notogastral setae whip-like, barbed unilaterally; RLN (relative length to notogaster) of them 19.4–26.4; setae  $c_3$  and  $d_3$  nearly as long as the distance  $c_3-d_3$ , longer than  $d_3-e_2$ .

**Anogenital region.** Genital plate divided into 2 plates by a transverse suture. Each part bearing 5 long setae. Anal and adanal plates separated, the former with 2 setae and the latter with 4 setae; anterior anal setae ( $an_2$ ) situated in a level between  $ad_3$  and  $ad_4$ ; posterior anal setae ( $an_1$ ) almost in the same level with  $ad_2$ . Praeanal plate broad transversely.

**Type series.** Holotype (NSMT-Ac 11851) and 6 paratypes (NSMT-Ac 11852–11854): Shiratani Unsui Valley, Yaku Island, the Ohsumi Islands, 31-VII-1981, H. Harada.

**Remarks.** The most characteristic feature of the new species is the shape of posterior exobothridial setae, which are lanceolate or narrow leaf-shaped. The setae in most of congeneric species are strongly rounded (as in *L. banksi* Norton, Metz & Sharma, 1978 and *L. jornoti* Mahunka, 1985) or broadly leaf-shaped (as in *L. bifoliata* Willmann, 1936, *L. embryonalis* Mahunka, 1978, *L. hispaniola* Pérez-Iñigo, 1967, *L. javana* Balogh, 1961, etc.). A few species have posterior exobothridial setae not broadened, but they are similar in shape to notogastral setae (as in *L. regalis* Berlese, 1923 and *L. reticulata* Mahunka, 1980). Only four species, *L. coreana* Choi, 1985, *L. serrata* Hu & Wang, 1989, *L. guzhanensis* Hu & Wang, 1989 and the new species, have posterior exobothridial setae which are lanceolate or nearly leaf-shaped. These three known species are, however, different from the new species as below: *L. coreana* has rostral setae longer than lamellar setae ( $le/ro=0.97$ ), *L. serrata* has longer notogastral setae (RLN of the longest setae 30.7) and seta  $c_1$  longer, or as long as, distance between  $c_1$  and  $d_1$ , and *L. guzhangensis* has rostral setae as long as lamellar setae and smaller body size (866–876  $\mu\text{m}$ ). The presence of six porous

areas on prodorsum is also a characteristic feature of the new species.

### *Hoplophthiracarus insularis* sp. nov.

(Figs. 8–12)

**Measurement.** Length of notogaster 450–510  $\mu\text{m}$ , length of aspis 250–265  $\mu\text{m}$ .

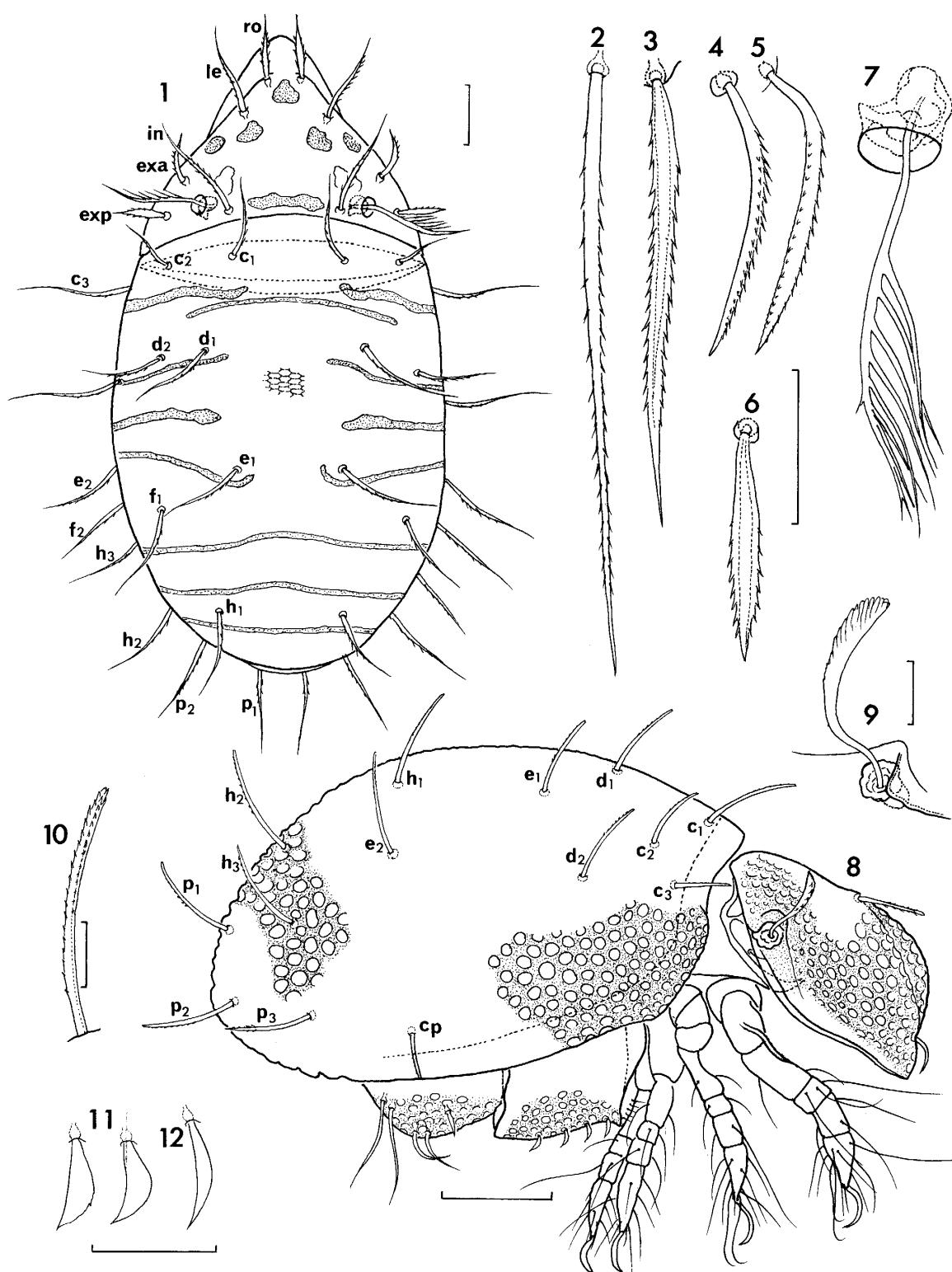
**Aspis.** Median ridge well developed. Interlamellar seta rod-like or weakly bending, 21–26% in length of aspis. Rostral seta curved downward, shorter than interlamellar setae (Fig. 8). Sensillus bearing a weakly swollen and splintery apical part (Fig. 9). Posterior half of bothridium covered by bothridial scale with a rectangular margin. A faint lateral carina making a rounded or angular curve over bothridium. Surface of aspis covered by distinct foveolae larger in middle and smaller in posterior and lateral parts.

**Notogaster.** Rather elongate in lateral view, covered by distinct large foveolae, interspace of them dark-colored. Fourteen pairs of notogastral setae rather thick, weakly bending forward and blunt at tip (Fig. 10).

**Anogenital region.** Genital setae  $g_1-g_5$  fine, arranged on the anterior edge; setae  $g_6-g_9$  leaf-shaped (Fig. 11), inserted on median margin of genital plate. Adanal setae  $ad_1$  and  $ad_2$  long, inserted close together in the posterior part of anoadaanal plate; seta  $ad_3$  short, somewhat leaf-shaped (Fig. 12); anal setae  $an_1$  and  $an_2$  medium long, inserted close together and bending anteriad.

**Type series.** Holotype (NSMT-Ac 12022) and 1 paratype (NSMT-Ac 12023): Southern part of Tokashiki Island, the Okinawa Islands, 14-XII-2004, J. Aoki.

**Remarks.** The new species is readily distinguishable from the known species of the genus *Hoplophthiracarus* by (1) dark-colored body, (2) very distinct and large foveolae on the body surface, (3) leaf-like genital setae  $g_6-g_9$ , (4) adanal setae  $ad_1$  and  $ad_2$  inserted close together and located far posteriorly.



Figs. 1–7. *Lohmannia unsui* sp. nov. 1: Dorsal view of body. 2: Lamellar seta. 3: Rostral seta. 4 and 5: Anterior exobothridial setae (exa). 6: Posterior exobothridial seta. 7: Sensillus. Fig. 8–12. *Hoplophthiracarus insularis* sp. nov. 8: Lateral view. 9: Sensillus and bothridium. 10: Notogastral seta. 11: Posterior genital setae. 12: Anterior adanal seta. Scale bars: 100  $\mu\text{m}$  in Figs. 1 and 8, 50  $\mu\text{m}$  in Figs. 2–7, 20  $\mu\text{m}$  in Figs. 9–12.

*Trhypochthonius javanus* Csiszár, 1961

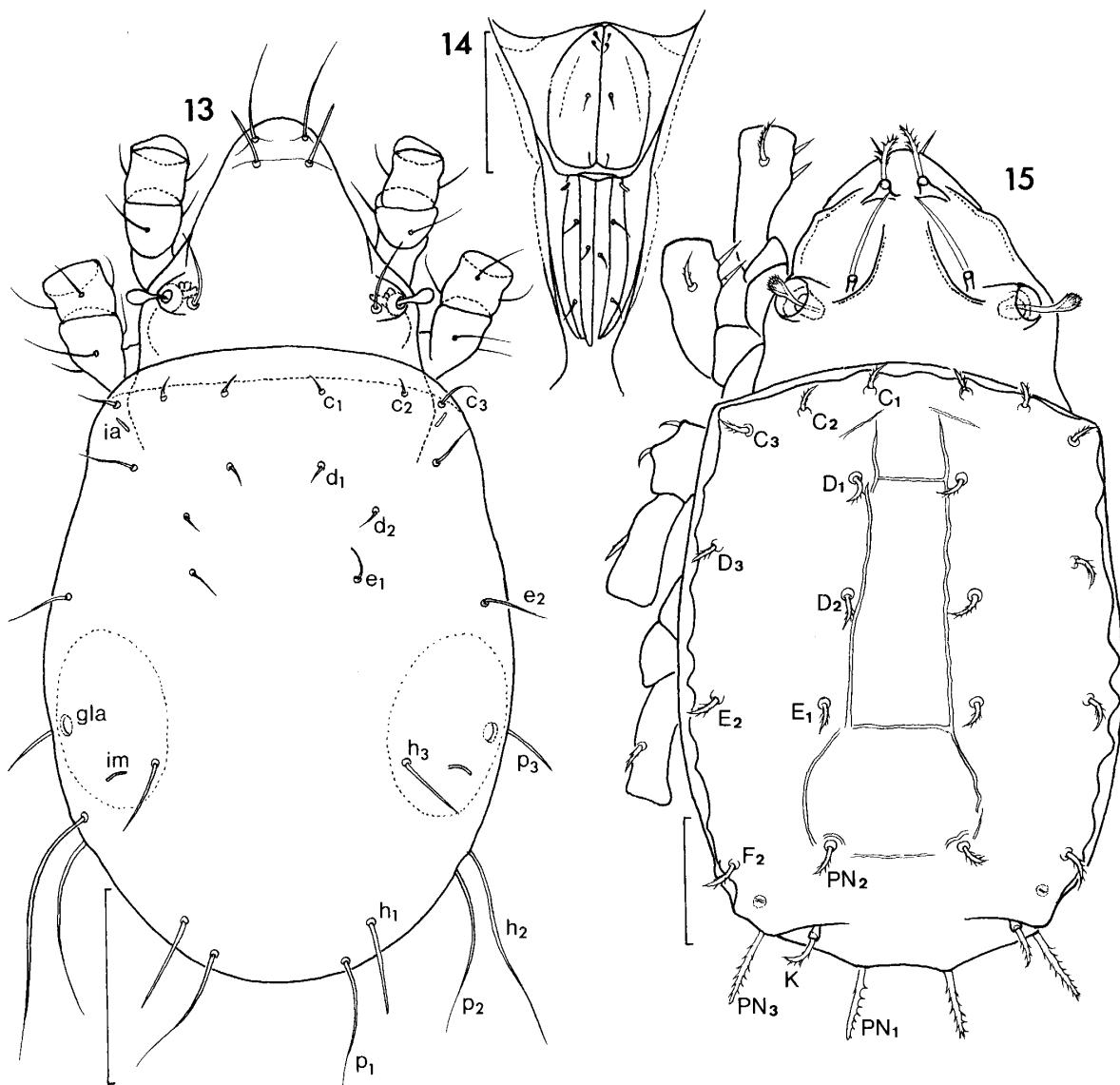
(Figs. 13–14)

*Trhypochthonius javanus* Csiszár, 1961: 349,  
fig.10.*Measurement.* Body length 590  $\mu\text{m}$ , width 330  $\mu\text{m}$ .*Remarks.* The Japanese specimen is well in accord with the original description of *Trhypochthonius javanus* from Java in having clavate sensilli, especially long notogastral setae  $h_3$  and  $ps_3$ , and notogaster weakly constricted near humeral part (Fig. 13). The only difference between them is in that interlamellar setae of the

Japanese specimen are not so long as those of the Javanese ones. Csiszár (1961) did not mention on the number of genital setae, but only four pairs of the setae are found on the Japanese specimen (Fig. 14).

*Specimen examined.* One specimen: North-eastern part of Tokashiki Island, the Okinawa Islands, 6-XII-2004, J. Aoki.*Distribution.* Java and Japan (new record).*Camisia invenusta* (Michael, 1888)

(Fig. 15)

*Nothrus invenustus* Michael, 1888: 500.Figs. 13–14. *Trhypochthonius javanus* Csiszár, 1961. 13: Dorsal view of body. 14: Anogenital region. Fig. 15.*Camisia invenusta* (Michael, 1888). Dorsal view of body. Scale bars: 100  $\mu\text{m}$  in Figs. 13–15.

*Camisia invenusta*: Sellnick & Forsslund, 1955: 488, Fig. 13; Sitnikova, 1975: 76, fig. 123; Balogh & Mahunka, 1983: 188, pl. 113, fig. C.

*Measurement*. Body length 530–650  $\mu\text{m}$ , width 310–360  $\mu\text{m}$ .

Prodorsum. Rostral seta short, Glabrous, directed anterolaterally. Lamellar seta thick, with strong spines and inserted on a small but distinct apophysis. Interlamellar seta long, reaching just apophysis of lamellar seta, also inserted on a small apophysis. A pair of longitudinal ridge found in the middle part of prodorsum, each curving posteriorly and approaching apophysis of interlamellar seta. Lamellar seta thick, with strong spines and inserted on a small but distinct apophysis. Interlamellar seta long and glabrous, reaching just apophysis of lamellar seta. Sensillus short, bearing a rounded head with fine barbs.

Notogaster. Notogaster broad, nearly rectangular, with gently arched anterior margin, strongly undulating lateral margins and weakly angulate posterior margin. Fifteen pairs of notogastral setae (two pairs visible only in ventral aspect); the posteriormost two pairs rather long and straight, with strong spines, the remaining 13 pairs short, barbed and curved. A pair of longitudinal ridges found in the middle part of notogaster, between setal lines D<sub>1</sub>–D<sub>2</sub>–E<sub>1</sub>; the ridges extending posteriorly to make a weak arch on each side and reaching insertion of seta PN<sub>2</sub>; the ridges connected by weak transverse ridges at levels of D<sub>1</sub>, E<sub>1</sub> and PN<sub>2</sub>; seta K<sub>1</sub> inserted on a small apophysis located just behind a transverse edge of posterolateral corner of notogaster.

Anogenital region. Nine pairs of genital setae, 2 pairs of aggenital setae, 3 pairs of anal setae and 3 pairs of adanal setae. Setae *an*<sub>1</sub> and *ad*<sub>2</sub> as well as *an*<sub>3</sub> and *ad*<sub>3</sub> situated nearly on the same level.

*Specimens examined*. Fourteen specimens: Near the top (1710 m) of Mt. Nageshi-dake, Yaku Island, the Ohsumi Islands, 30-VII-1981, J. Aoki. From the soil under the alpine grassland of *Dioscorea carex* and *Miscanthus*.

*Distribution*. Britain, Sweden, Faeroe Island, Switzerland, Soviet Union, Poland and Japan

(new record).

### *Neoliodes bataviensis* Sellnick, 1925

(Figs. 16–17)

*Neoliodes bataviensis* Sellnick, 1925: 463, figs. 7–9.

*Measurement*. Body length 1040–1100  $\mu\text{m}$ , width 710–800  $\mu\text{m}$ .

*Remarks*. This species is easily recognized by the structure on prodorsum, a pair of swellings well separated by a rather wide interspace (Fig. 16) and rod-like sensilli without distinctly thickened head (Fig. 17). Sculpture on notogaster is obscure except for lateral striae consisting of faint granules, ridges and longitudinal furrows on anteromedian part.

*Specimens examined*. Nine specimens: Ohkaneku Beach, Yoron Island, the Amami Islands, 19-I-1980, J. Aoki.

*Distribution*. Java, Australia and Japan (new record).

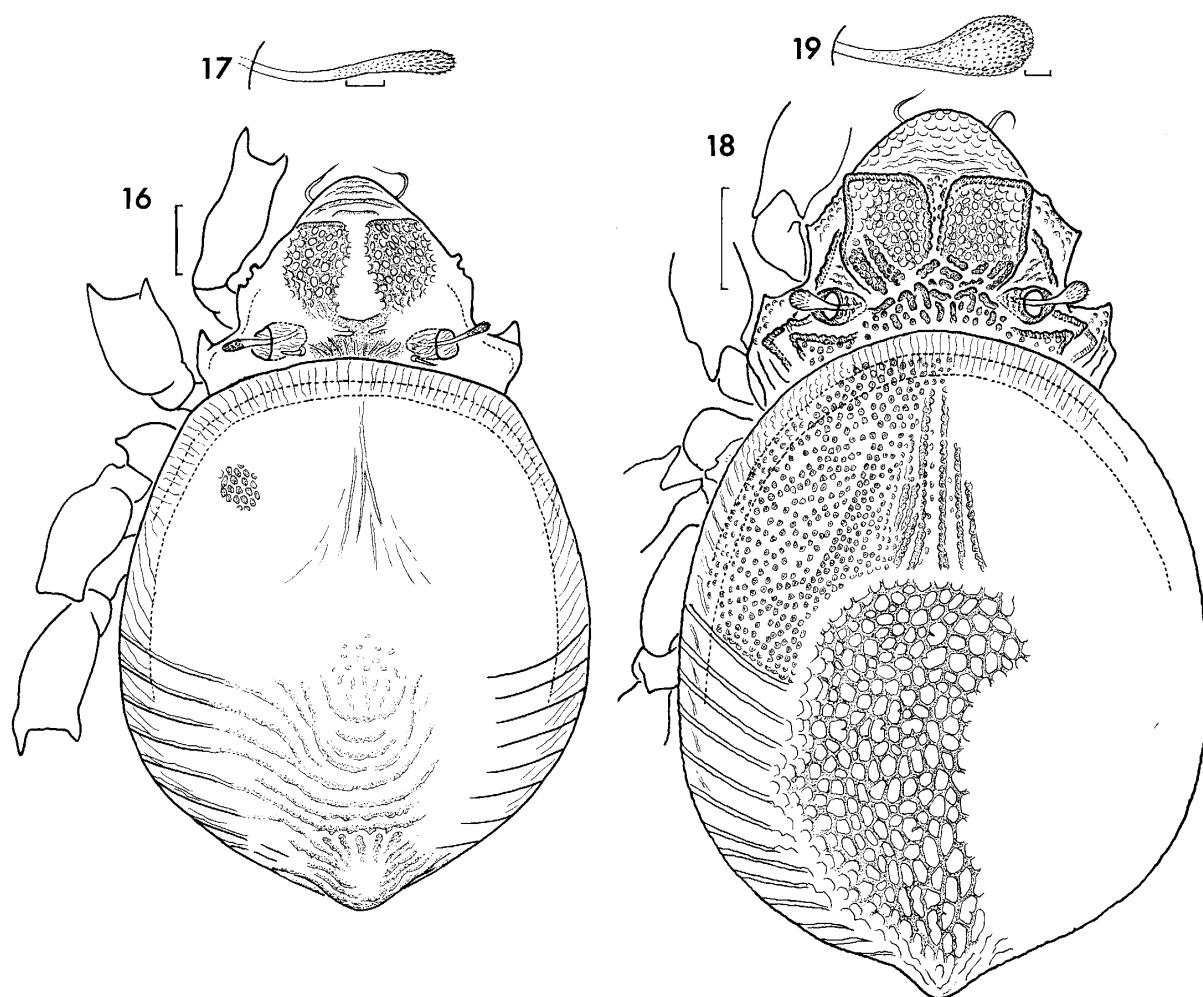
### *Neoliodes striatus* (Warburton, 1912)

(Figs. 18–19)

*Neoliodes striatus* Warburton, 1912: 357, pl. 19, fig. 23.

*Measurement*. Body length 800–910  $\mu\text{m}$ , width 515–590  $\mu\text{m}$ .

*Remarks*. The original description by Warburton is short and simple, but the characteristic features of the species were mentioned enough. The extract from his description: "Samaller body size about 0.9 mm, pitted cephalothorax, pseudostigmatic organ with oval head, abdomen widest near the posterior end, with a short, blunt, caudal process arising from a raised pitted oval area, and anterior median field exhibits a few longitudinal striae." This is well in accord with the features of the Japanese specimens. The only difference is in the anterior median field which is "deeply pitted" in the Warburton's description and "densely granulate" in the Japanese specimens. The longitudinal striae on the anteromedian field of notogaster are, however, formed by longitudinal fu-



Figs. 16–17. *Neoliodes bataviensis* Sellnick, 1925. 16: Dorsal view of body. 17: Sensillus. Figs. 18–19. *Neoliodes striatus* (Warburton, 1912). 18: Dorsal view of body. 19: Sensillus. Scale bars: 100 µm in Figs. 16 and 18, 20 µm in Figs. 17 and 19.

sion of many granules (Fig. 18).

*Specimens examined.* Six specimens: Ugan in Aguni Island, the Okinawa Islands, 5-XII-2005, J. Aoki. From bark of a dead tree in a natural forest.

*Distribution.* The Seychelles Islands and Japan (new record).

#### *Sadocepheus yakuensis* sp. nov. (Figs. 20–22)

*Measurement.* Body length (lamellae excluded) 750 µm, width 620 µm.

*Prodorsum.* Lamellae broad, extending well beyond rostral tip; lamellar cusps well separated, median margins weakly undulated, bearing each an incurved lamellar seta. Rostral setae very short and fine, invisible from above, covered by

lamellar cusps. Interlamellar setae thick and long, reaching mid-distance along the length of lamellae (Fig. 20). Sensillus slender, rod-like, almost of the same thickness throughout its length, gently curved in proximal portion, strongly barbed apically (Fig. 21).

*Notogaster.* Notogaster broad, wider than long. Anterior margin straight, consisting of triple transverse ridges. Humeral appendage well developed, forming three lateral arches, the third one pointed at tip. Nine pairs of notogastral setae: 5 pairs of them thick and long, situated rather laterally on dorsal side and each of them longer than distance to succeeding seta; one posteriormost pair shorter and thinner (Fig. 20); the remaining 3 pairs visible only in ventral aspect, very short and fine, situated close to margin of

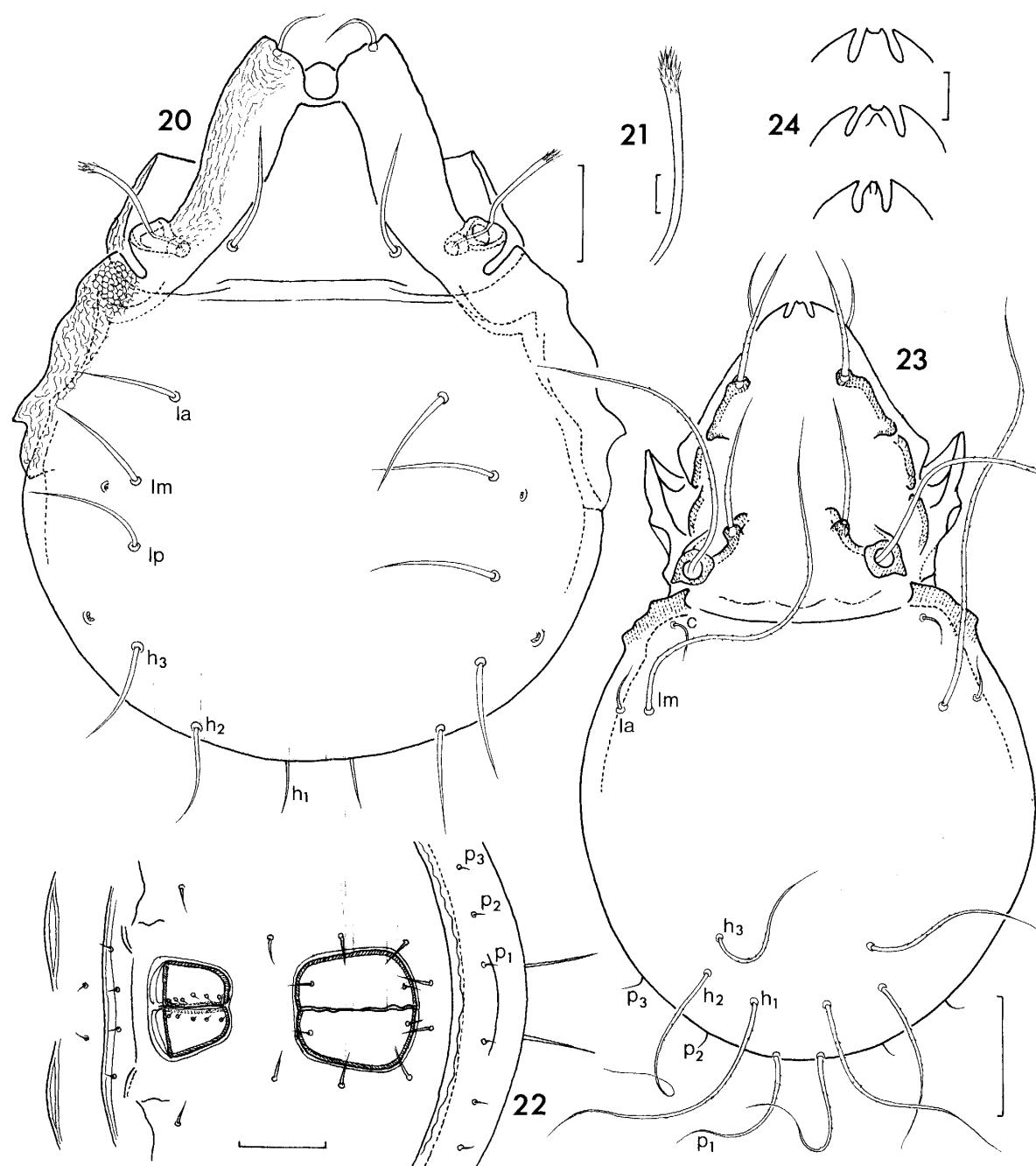
ventral plate (Fig. 22).

Anogenital region. Genital aperture wider anteriorly, with straight lateral margins. Genital plate framed with a strong, dark-colored ridge; the anterior part of frame straight. In the single specimen examined, the number of genital setae 5 on the right side and 6 on the left side (6 must be the normal number). All the setae minute and fine. Anal plate also framed with a dark ridge;

two short anal setae situated far anteriorly and posteriorly, respectively. Three pairs of adanal setae longer than anal setae (Fig. 22).

*Type.* Holotype (NSMT-Ac 11862): Shiratani Unsui Valley, Yaku Island, the Okinawa Islands, 8-2003. J. Aoki.

*Remarks.* Most of the known species of the genus *Sadocepehus* have minute interlamellar setae. Only *S. granulatus* (Balogh & Mahunka,



Figs. 20–22. *Sadocepehus yakuensis* sp. nov. 20: Dorsal view of body. 21: Sensillus. 22: Anogenital region. Figs. 23–24. *Defectamerus insularis* sp. nov. 23: Dorsal view of body. 24: Variations in rostral tips. Scale bars: 100  $\mu\text{m}$  in Figs. 20, 22 and 23, 20  $\mu\text{m}$  in Figs. 21 and 24.

1969) and *S. franzi* (P. Balogh, 1986) have long interlamellar setae as in the new species. They are, however, distinguishable from the new species by the humeral appendages strongly projecting anterolaterally and long genital setae. The remaining species with minute interlamellar setae are also distinguishable from the new species by one of the following features: (1) sensilli without apical barbation, (2) lamellar cusps situated close to each other and (3) undulating dorsal setae.

*Defectamerus insularis* sp. nov.

(Figs. 23–24)

**Measurement.** Body length 605–665  $\mu\text{m}$ , width 350–420  $\mu\text{m}$ .

Prodorsum. Rostrum tongue-shaped between incisions, often notched at tip in various ways (Fig. 24). Lamellar ridge has an anterior apophysis with lamellar seta and small posterior tooth. Lamellar setae thick, nearly as long as their mutual distance, inserted each on an apophysis. Two more pairs of ridges found posterior to lamellar ridges. Interlamellar setae as thick as and a little longer than lamellar setae, longer than their mutual distance, inserted each on a distinct apophysis. Bothridium with posterolateral tooth. Sensillus long and whip-like. All the prodorsal setae slightly barbed.

Notogaster. Nine pairs of notogastral setae; setae *lp* absent; 5 pairs of them (*lm*, *h<sub>1</sub>*–*h<sub>3</sub>*, *p<sub>1</sub>*) long and whip-like, the remaining 4 pairs (*c<sub>2</sub>*, *la*, *p<sub>2</sub>*, *p<sub>3</sub>*) short; among the long setae, *lm* extraordinarily long, nearly as long as notogaster; *h<sub>1</sub>* the second longest, distinctly longer than the remaining long setae (*h<sub>2</sub>*, *h<sub>3</sub>* and *p<sub>1</sub>*) (Fig. 23).

Anogenital region. Anogenital chaetotaxy: 6–1–2–3. Mutual distance *ag*–*ag* a little longer or shorter than *ad<sub>1</sub>*–*ad<sub>1</sub>*, always longer than *ad<sub>3</sub>*–*ad<sub>3</sub>*.

**Type series.** Holotype (NSMT-Ac 11866) and 2 paratypes (NSMT-Ac 11867–11868): Northern slope of Mt. Yoko-dake, Kuchinoshima Island of the Tokara Islands, 19-III-1987, J. Aoki—1 paratype (NSMT-Ac 11869): Zamami Island of the Okinawa Islands, 6-X-2005, J. Aoki.

**Remarks.** The new species is peculiar in having five long notogastral setae including setae *p<sub>1</sub>*. The five long setae of the known species (*D. setata* Berlese, 1916, *D. qinlingensis* Chen et al., 2004, *D. lindquisti* Chen et al., 2004 and *D. yunnanensis* Aoki & Yamamoto, 2000) are always *lm*, *lp*, *h<sub>1</sub>*, *h<sub>2</sub>* and *h<sub>3</sub>* and not *lm*, *h<sub>1</sub>*, *h<sub>2</sub>*, *h<sub>3</sub>* and *p<sub>1</sub>* as in the new species.

*Heteroppia setigera* sp. nov.

(Figs. 25–26)

**Measurement.** Body length 590–640  $\mu\text{m}$ , width 340–390  $\mu\text{m}$ .

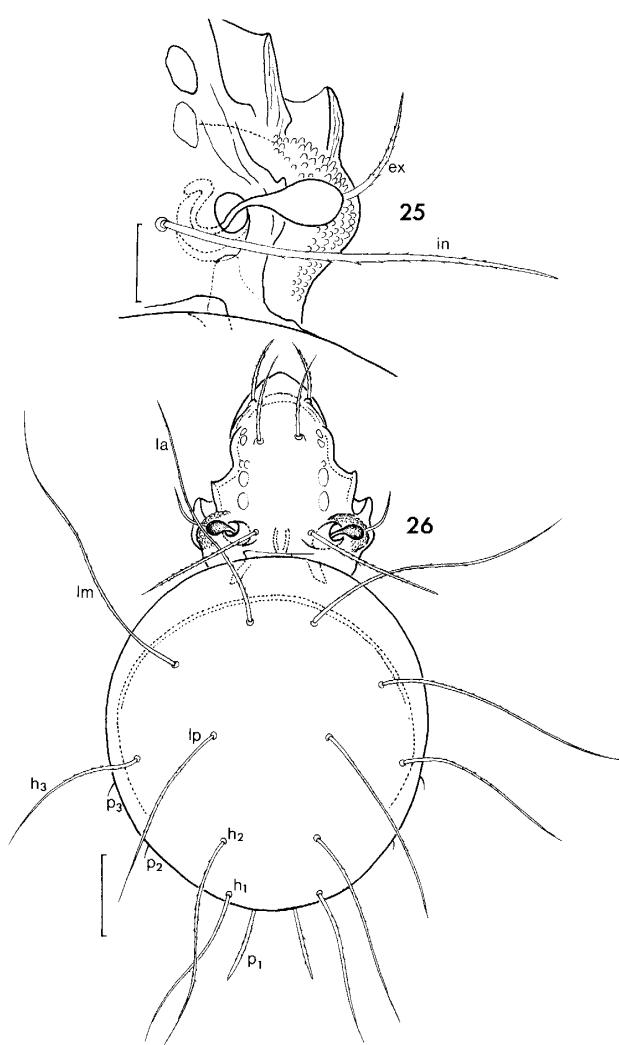
Prodorsum. Rostral setae rather thick, barbed, nearly as long as their mutual distance. Lamellar setae thinner than rostral setae, almost twice as long as rostral ones and their mutual distance. Interlamellar setae straight, twice as long as lamellar setae (Fig. 26). Sensillus with a short peduncle and a large oval head (Fig. 25). Exobothridial setae rather long and curled anteriad. The lateral part outside bothridia strongly swollen, densely covered with granules. Several light spots found laterally on prodorsum. A pair of short indistinct longitudinal ridges found medially between bothridia.

Notogaster. Notogaster rounded, with a broad dark-colored band anteriorly; a rectangular ridge found on anterior margin of notogaster. Six pairs of very long whip-like dorsal setae (*da*, *dm*, *dp*, *h<sub>1</sub>*, *h<sub>2</sub>* and *h<sub>3</sub>*), a pair of shorter, thicker posterior setae (*p<sub>1</sub>*) and 2 pairs of minute posterolateral setae (*p<sub>2</sub>* and *p<sub>3</sub>*); their length ( $\mu\text{m}$ ): *da* 280, *dm* 400, *dp* 215, *h<sub>1</sub>* 200, *h<sub>2</sub>* 250, *h<sub>3</sub>* 175, *p<sub>1</sub>* 95, *p<sub>2</sub>* 10, *p<sub>3</sub>* 10.

Anogenital region. Genital aperture small, wider posteriorly than anteriorly, with 6 pairs of fine setae. Two pairs of anal setae; *an<sub>2</sub>* longer than *an<sub>1</sub>*; mutual distance *an<sub>2</sub>*–*an<sub>2</sub>* > *an<sub>1</sub>*–*an<sub>1</sub>*. Three pairs of adanal setae; mutual distance *ad<sub>3</sub>*–*ad<sub>3</sub>* > *ad<sub>2</sub>*–*ad<sub>2</sub>*. Adanal fissure *iad* close and pararell to lateral margin of anal opening, located in level with anal seta *an<sub>2</sub>*. Aggenital setae far longer than adanal setae.

**Type series.** Hototype (NSMT-Ac 11873): Mt.

(five pairs).



Figs. 25–26. *Heteroppia setigera* sp. nov. 25: Lateroposterior part of prodorsum (right side). 26: Dorsal view of body. Scale bars: 30  $\mu\text{m}$  in Fig. 25, 100  $\mu\text{m}$  in Fig. 26.

Omoto, Ishigaki Island, the Yaeyama Islands, 5-X-1978, J. Aoki—1 paratype (NSMT-Ac 12014); Mariudo Fall, Iriomote Island, the Yaeyama Islands, 23-VI-2005, J. Aoki.

**Remarks.** Three species have hitherto been known in the genus *Heteroppia*, which is characterized by globose sensilli and very long whip-like notogastral setae. These long setae in the new species are six pairs, while they are four pairs in *H. globigera* Balogh, 1970, from Fiji Island. The remaining species, *H. orthodactyla* Willmann, 1932, from Java, must have five pairs of long notogastral setae, though all the setae except those of *p*-series were broken and lost in the type specimen, leaving only their insertion pores

### *Dolicheremaeus magnus* sp. nov.

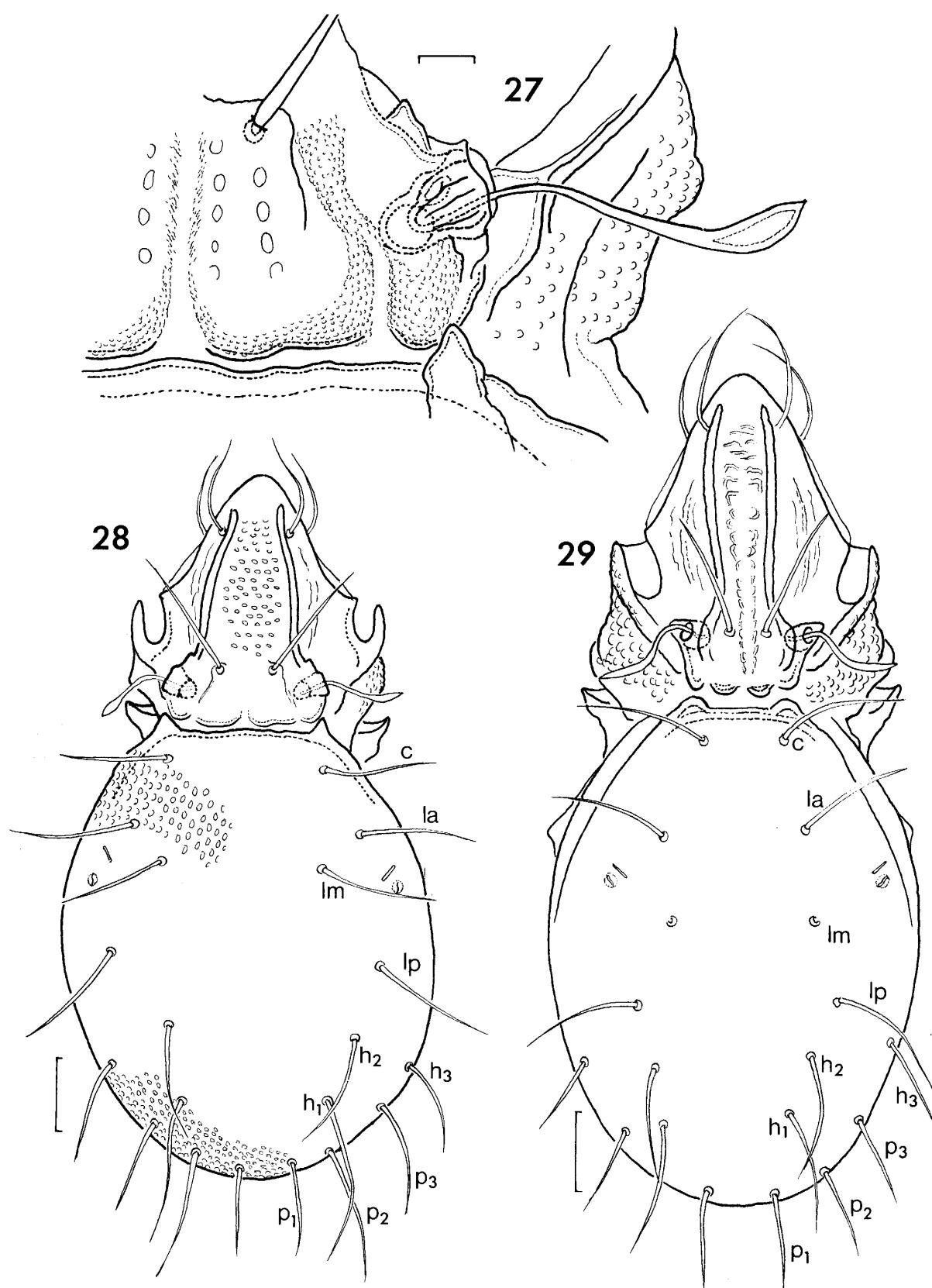
(Figs. 27–28)

**Measurement.** Body length 900–950  $\mu\text{m}$ , width 480–525  $\mu\text{m}$ .

**Prodorsum.** Rostrum without a marginal rim. Rostral setae densely barbed unilaterally. Lamellae thin. Lamellar setae longer than their mutual distance, densely barbed unilaterally, curved inward near the base, inserted a short distance behind lamellar tip. Interlamellar setae thick, straight, weakly barbed, 2.6–2.7 times as long as their mutual distance. Prodorsal surface densely foveolate; the foveolae becoming smaller in anterior part and arranged more sparsely in posterior part (Fig. 28). Fine and dense granules found along lamellae, around bothridia and near posterior margin of prodorsum. Bothridium opening laterally, accompanied by short anterior and posterior ridges. Sensillus with a long thin pecuncle and a spindle-shaped head (Fig. 27). Exobothridial setae very short and fine. Prodorsal condyles very poorly developed; *co.pl* triangular; *co.pm* discernible as very low and broad protrusions.

**Notogaster.** Notogaster large and broad, about 1.2 times as long as wide. Notogastral condyles very poorly developed; *co.nl* triangular; *co.nm* absent; anterior margin of notogaster showing only weakly waving margin. Notogastral surface covered with inconspicuous foveolae and fine striae like “capillaries”. Ten pairs of notogastral setae rather thick and long, weakly barbed; their RLN (relative length to notogaster, %): 17.1–36.2; seta *da* longer than *c*; *h<sub>1</sub>* longer than *h<sub>2</sub>*; *p<sub>2</sub>* longer than *p<sub>1</sub>* or *p<sub>3</sub>*. Lyrifissure *im* in level with seta *dm*.

**Anogenital region.** Genital plates glabrous, with 4 pairs of setae; mutual distance *g<sub>1</sub>–g<sub>1</sub>* = *g<sub>2</sub>–g<sub>2</sub>* < *g<sub>4</sub>–g<sub>4</sub>* < *g<sub>3</sub>–g<sub>3</sub>*. Anal plates weakly foveolate, with 2 pairs of setae; mutual distance *an<sub>2</sub>–an<sub>2</sub>* far longer than *an<sub>1</sub>–an<sub>1</sub>*. Adanal setae *ad<sub>3</sub>* inserted in level posterior to anterior margin of anal opening and in level with adanal fissures



Figs. 27–28. *Dolicheremaeus magnus* sp. nov. 27: Lateroposterior part of prodorsum (right side). 28: Dorsal view of body. Fig. 29. *Dolicheremaeus orientalis* (Aoki, 1965). Dorsal view of body. Scale bars: 100  $\mu\text{m}$  in Figs. 28 and 29, 20  $\mu\text{m}$  in Fig. 27.

*iad.*

*Type series.* Holotype (NSMT-Ac 11874) and 1 paratype (NSMT-Ac 11875): U.S. Army Base in Agari-son, Okinawa Island, 21-IX-1996, J. Aoki.—1 paratype (NSMT-Ac 12015): Shiratani Unsui Valley, Yaku Island, the Ohsumi Islands, 8-X-2003, J. Aoki.

*Remarks.* In the complete absence of median notogastral condyles and the presence of very weakly developed median prodorsal condyles, the new species resembles *D. porcinolus* Aoki, 1967, *D. inopinatus* Aoki, 1967, *D. nepalensis* Aoki, 1967 (all from Nepal) and *D. euensis* Hammer, 1973 (from Eua Island). However, sensilli of *D. nepalensis* has no swollen head and those of *D. porcinolus* has a head only slightly swollen. Notogastral setae of *D. procinolus* with curled tip and notogastral neotrichy in *D. nepalensis* are also characteristic. Notogastral setae of *D. inopinatus* and *D. euensis* are far shorter than those of the new species. Sensilli of *D. inopinatus* have unpointed tip. Median prodorsal condyles of *D. euensis* are fused in a single transverse ridge, not divided into two parts.

#### *Dolicheremaeus orientalis* Aoki, 1965

(Fig. 29)

*Tetracondyla orientalis* Aoki, 1965: 172, figs. 67–72.

*Measurement.* Body length 1040  $\mu\text{m}$ , width 470  $\mu\text{m}$ .

*Remarks.* The present species was originally described from the northern part of Thailand (Doi Suthep) and it is recorded for the first time from Japan. The most characteristic features of the species are (1) rounded lateral notogastral condyles (*co.nl*), (2) absence of median notogastral condyles (*co.nm*), and (3) sensilli directed at first posteriorly and then laterally.

*Specimens examined.* Three specimens: Arakawa, Yonaguni Island, the Yaeyama Islands (collecting date unknown), G. Imadate.

*Distribution.* Thailand and Japan (new record).

#### *Fissicepheus gracilis* sp. nov.

(Figs. 30–32)

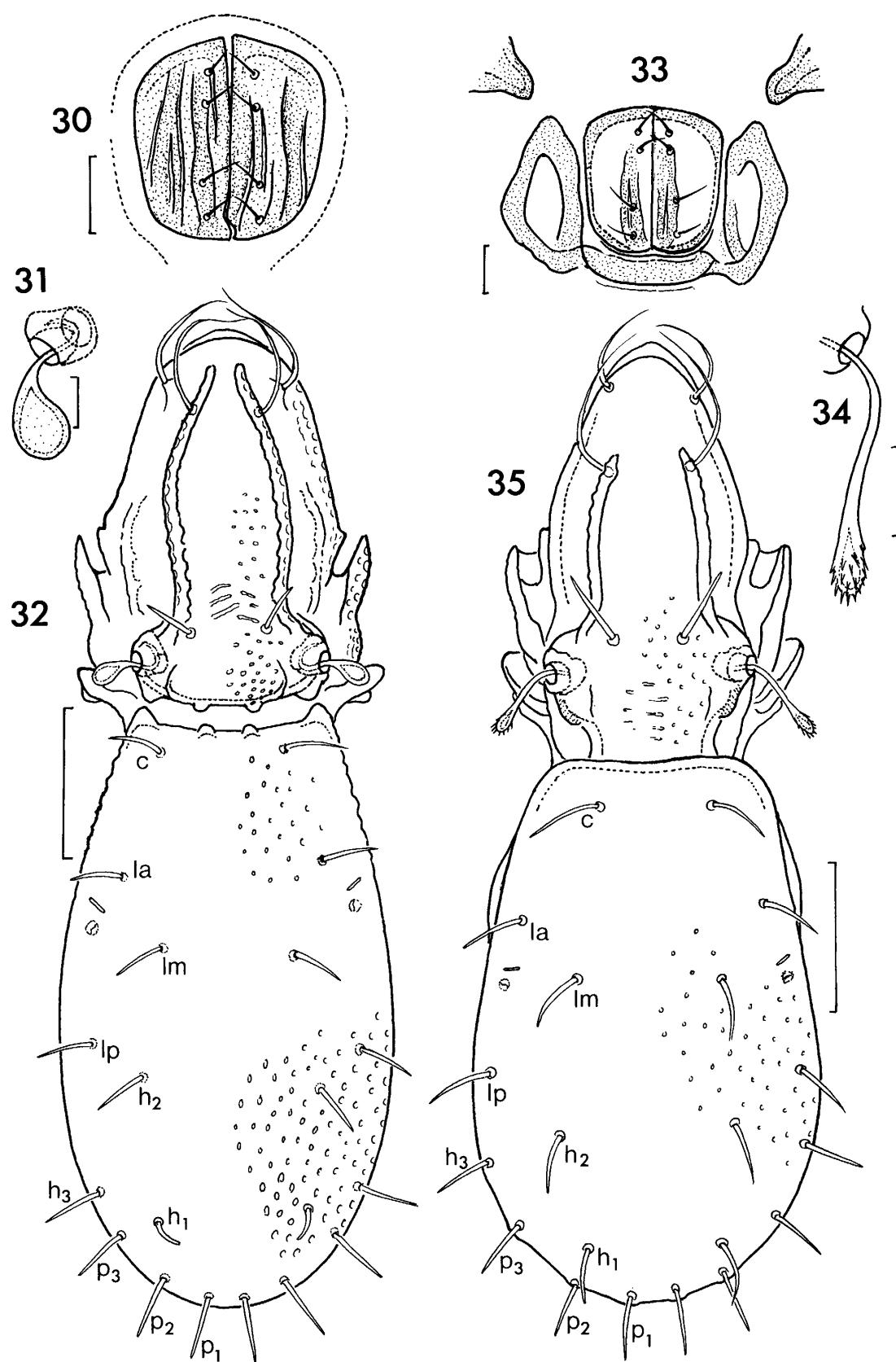
*Measurement.* Body length 600–735  $\mu\text{m}$ , width 208–255  $\mu\text{m}$ .

*Prodorsum.* Upper edge of rostrum broadly rounded; lower edge a little projecting beyond the former and, in lateral view, only weakly undulating on ventral margin. Lamellar ridges weakly sigmoid, becoming closer to each other anteriorly. Rostral and lamellar setae long and whip-like; the former inserted on a distinct apophysis. Interlamellar setae short and rod-like, shorter than their mutual distance. area between lamellae sparsely punctuate, the punctures becoming more densely distributed posteriorly between bothridia and fused to form some transverse furrows in front of interlamellar setae (Fig. 32). Sensillus with a strongly rounded head and a short peduncle; the head nearly glabrous, only slightly roughened (Fig. 31). Two pairs of prodorsal condyles; *co.pl* triangular and *co.pm* small and semicircular, being connected by a transverse ridge. An arched swelling found between *co.pl* and *co.pm*.

*Notogaster.* Notogaster elongate, becoming narrower anteriorly; L/W of notogaster=1.69–1.84. Two pairs of notogastral condyles; *co.nl* triangular and *co.nm* small and rounded triangular. Anterior 1/4–2/5 of notogastral lateral margin roughened. The surface of notogaster sparsely punctured in anterior part, but the punctures becoming somewhat larger and denser posteriorly. Ten pairs of notogastral setae short and rod-like, weakly roughened and bluntly pointed at tip.

*Anogenital region.* Genital plates irregularly sculptured with several distinct longitudinal grooves (Fig. 30). Two pairs of aggenital condyles well developed. Anal plates sculptured with longitudinal grooves more finely and densely than on genital plates. Adanal setae similar in shape to notogastral setae; *ad*<sub>2</sub> situated closer to *ad*<sub>3</sub> than to *ad*<sub>1</sub>. Anal fissures *iad* aligned transversely.

*Type series.* Hototype (NSMT-Ac 11834) and 10 paratypes (NSMT-Ac 11835–11841): Mt.



Figs. 30–32. *Fissicepheus gracilis* sp. nov. 30: Genital aperture. 31: Sensillus. 32: Dorsal view of body. Figs. 33–35. *Fissicepheus defectus* sp. nov. 33: Genital aperture and agenital condyles. 34: Sensillus. 35: Dorsal view of body. Scale bars: 100  $\mu$ m in Figs. 32 and 35, 20  $\mu$ m in Figs. 30, 31, 33 and 34.

Nishime-dake, Okinawa Island, 20-X-1996, J. Aoki.

*Remarks.* The new species is similar to *F. clavatus* (Aoki, 1959), but distinguishable from the latter by (1) smaller and more slender body, (2) more broadly rounded rostral margin, (3) lower edge of rostral margin not so distinctly toothed, (4) shorter sensilli with more strongly swollen head, and (5) genital and anal plates distinctly sculptured with longitudinal grooves.

***Fissicepheus defectus* sp. nov.**

(Figs. 33–35)

*Measurement.* Body length 585–760 µm, width 230–330 µm.

Prodorsum. Lamellae terminating far behind rostral tip. Lamellar seta thicker than rostral seta, inserted almost at tip of lamella. Interlamellar setae thick, blunt at tip, a little longer than their mutual distance (Fig. 35). Sensillus bearing a long peduncle and a swollen head with many strong spines (Fig. 34). Condyles in the posterior part very poorly developed; only *co.pl* discernible as a low triangle; no *co.pm* present. A weak longitudinal ridge found posteromedially of bothridium on each side.

Notogaster. Notogaster elongate, becoming narrower anteriorly. A weak swelling found under humeral part on each side. Notogastral condyles completely absent. Ten pairs of notogastral setae short and rod-like, bluntly pointed at tip. Insertion places of setae *p<sub>1</sub>*, *p<sub>2</sub>* and *p<sub>3</sub>* somewhat swelling out to give the appearance of notogastral margin weakly angulate. Notogastral surface showing punctures sparsely in anterior part and densely in posterior part.

Anogenital region. Genital plate bearing medially a longitudinal thickening, on which 4 genital setae are inserted; setae *g<sub>1</sub>* and *g<sub>2</sub>* close to each other, while *g<sub>3</sub>* and *g<sub>4</sub>* well separated. Aggenital condyles strikingly well developed, posterior condyles forming a thick diamond-shaped ridge on each side of genital opening (Fig. 33). Aggenital setae thick and barbed. Anal plates densely punctuate. Two pairs of anal setae short and

rather thick; anterior pair (*an<sub>2</sub>*) inserted close to anterior margin of plate. Adanal fissures aligned transversely.

*Type series.* Holotype (NSMT-Ac 11842) and 2 paratypes (NSMT-Ac 11843–11844): Mt. Nishime-dake, Okinawa Island, 20-X-1996, J. Aoki; 17 paratypes (NSMT-Ac 11855–11861): Mt. Yonaha-dake, Okinawa Island, 21-I-1991, J. Aoki; 1 paratype (NSMT-Ac 11845): Tokashiki Island, the Okinawa Islands, 14-XII-2004. J. Aoki.

*Remarks.* The new species is easily distinguishable from the known congeners by (1) poor development of prodorsal condyles (only weak *co.pl* are discernible) and complete absence of notogastral condyles and (2) peculiar aggenital condyles strongly developed to form a pair of ring-like structures. Only *F. steinmanni* Mahunka, 1971 from Korea is similar to the new species in lack of notogastral condyles and in having aggenital condyles strongly developed. The Korean species, however, differs from the new species in strongly swollen head of sensilli and deeply excised rostral tip.

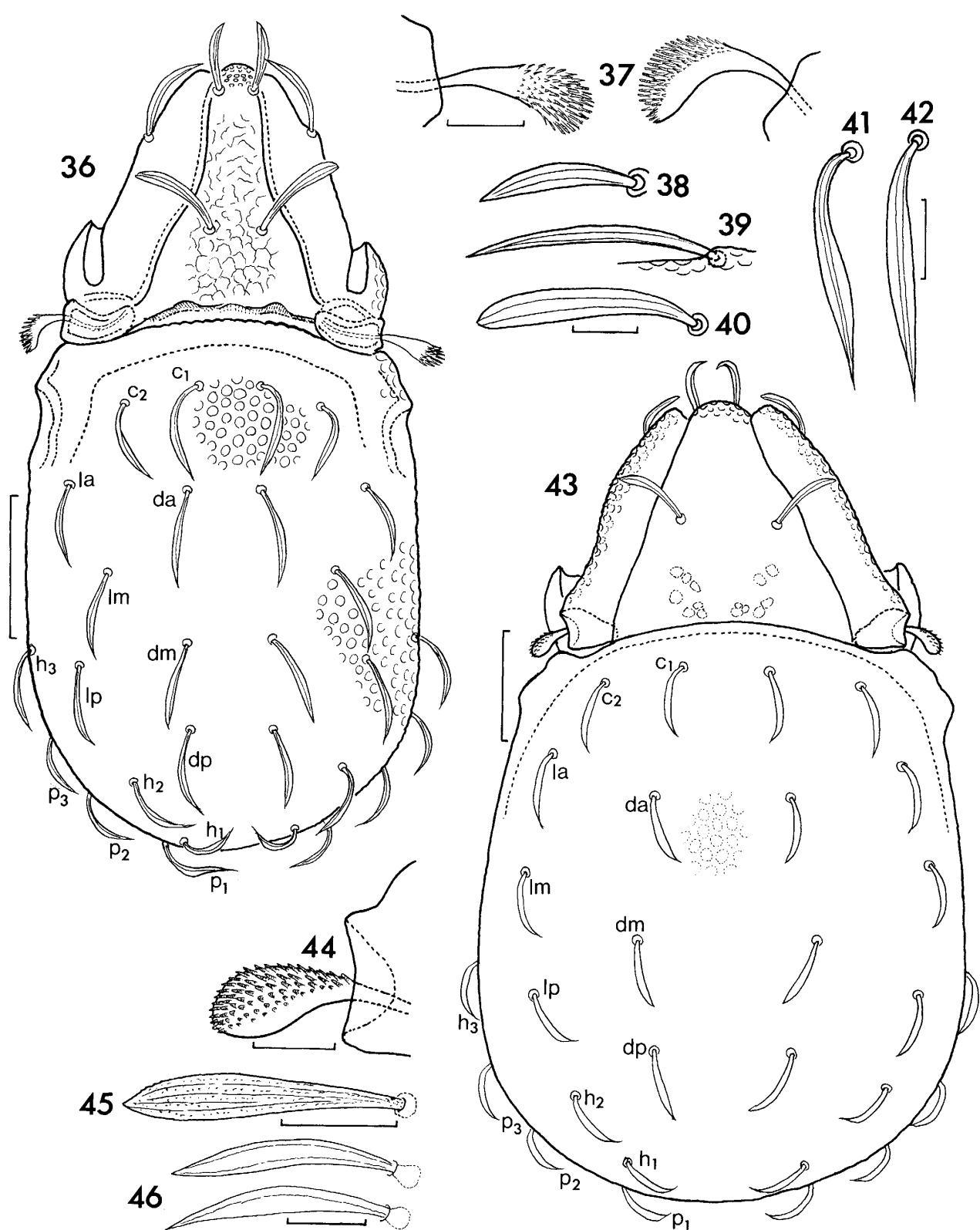
***Austrocarabodes bituberculatus* sp. nov.**

(Figs. 36–42)

*Measurement.* Body length 550–570 µm, width 280–300 µm.

Prodorsum. Rostral setae narrowly leaf-like (Fig. 38), short, but longer than their mutual distance. Lamellar setae (Fig. 39) inserted laterally, 1.5 times as long as rostral setae. Interlamellar setae (Fig. 40) becoming broader anteriorly, blunt at tip, bending outward, inserted close together and twice as long as their mutual distance. Middle field of prodorsum with irregular networks becoming more indistinct in the anterior part. A transverse ridge found in posterior part of prodorsum, having a small knobs on each side (Fig. 36). Sensillus short and bent backward, bearing a thickened head densely covered unilaterally with strong spines (Fig. 37).

Notogaster. Humeral appendages weakly developed. Fourteen pairs of notogastral setae nar-



Figs. 36–42. *Austrocabodes bituberculatus* sp. nov. 36: Dorsal view of body. 37: Sensilli. 38: Rostral seta. 39: Lamellar seta. 40: Interlamellar seta. 41: Notogastral seta c2. 42: notogastral seta c1. Figs. 43–46. *Austrocabodes obscurus* sp. nov. 43: Dorsal view of body. 44: Sensillus. 45: Interlamellar seta. 46: Notogastral setae. Scale bars: 100  $\mu\text{m}$  in Figs. 36 and 43, 20  $\mu\text{m}$  in Figs. 37–42, 44–46.

rowly leaf-like, with a distinct mid-rib and sharply pointed at tip. (Fig. 41–42). RLN (relative length to notogaster, %) of notogastral setae 15.3–22.2; setae  $c_1$  and  $da$  not reaching insertion pores of the succeeding setae  $da$  and  $dm$ , respectively, but  $dm$  and  $lm$  reaching those of setae  $dp$  and  $lp$ , respectively; setal distance  $c_1-c_2$  a little longer than  $c_1-c_1$ ; setae  $c_1 > c_1-c_1$ ;  $da=da-da$ ;  $dm=dm-dm$ ;  $da$  and  $la$  situated nearly in the same level.

Anogenital region. Genital aperture rectangular, with 4 pairs of thin and long setae; distance  $g_2-g_3$  longer than  $g_1-g_2$  as well as  $g_3-g_4$ . Aggenital setae also thin and long. Two pairs of anal setae lanceolate, shorter and thicker than genital setae; setae  $an_2$  inserted at mid-distance or a little anterior along the length of anal plates. Anal plates showing an indistinct network on surface. Three pairs of adanal setae narrowly leaf-like, similar in shape to rostral setae.

*Type series.* Holotype (NSMT-AC 11870) and 2 paratypes (NSMT-Ac 11871–11872): Kushiohkawa, Nago City, Okinawa Island, 17-XII-1998, J. Aoki.

*Remarks.* The new species is distinguishable from the other members of the genus *Austrocarabodes* by the following combination of characters: (1) interlamellar setae broadened toward tip and inserted close together, twice as long as their mutual distance, (2) short sensilli with swollen head strongly barbed, (3) rather long notogastral setae (RLN=1.53–2.22), (4) transverse posterior ridge on prodorsum with a pair of knobs.

#### *Austrocarabodes obscurus* sp. nov.

(Figs. 43–46)

*Measurement.* Body length 700–820  $\mu\text{m}$ , width 430–570  $\mu\text{m}$ .

Prodorsum. Rostrum rounded, foveolate on surface (Fig. 43). Rostral setae curved inward at tip. Lamellar setae a little longer than rostral ones. Interlamellar setae slender leaf-shaped (Fig. 45), weakly roughened with minute granules, nearly as long as their mutual distance. Lamellae weakly foveolate. Sensillus very short,

only swollen head exposed and most of peduncle concealed in bothridium; the head bending posteriad and densely bearing short thorns except on posterior side (Fig. 44). Surface of prodorsum mostly smooth, without special sculpture except for several light spots in posterior part.

Notogaster. Notogaster fat and short, widest rather in posterior part and broadly rounded on posterior margin. Anterior margin weakly arched. Humeral projections moderately developed. Fourteen pairs of notogastral setae rather short, slender leaf-shaped (Fig. 46); mutual distance  $e_1-e_1 > d_1-d_1 = f_1-f_1$ . Notogastral surface nearly smooth, showing very obscure network-like pattern.

Anogenital region. Genital opening nearly a square; 4 pairs of genital setae thin. Anal opening slightly wider posteriorly; 2 pairs of anal setae a little thickened. Median margin of each anal plate serrated in anterior half. Three pairs of adanal setae slender leaf-shaped as notogastral ones. Ventral plate with transverse wrinkles in front of anal aperture.

*Type series.* Holotype (NSMT-Ac 12019) and 2 paratypes (NSMT-Ac 12020–12021): Tonaki Island, the Okinawa Islands, 20-IV-2006, J. Aoki. From soil and roots of grasses growing on limestone cliff near the shore.

*Remarks.* The new species is very similar to *Austrocarabodes australis boninensis* (Aoki, 1978), especially in the shape of sensilli, but is distinguishable from the latter by the almost smooth body surface without granulous structure as that in the former species. The body size of the new species is larger than that of *A. australis boninensis* (body length: 616–672  $\mu\text{m}$ ).

#### *Eremaeozetes undulatus* Mahunka, 1985

(Fig. 47)

*Eremaeozetes undulatus* Mahunka, 1985: 134, figs. 27–28.

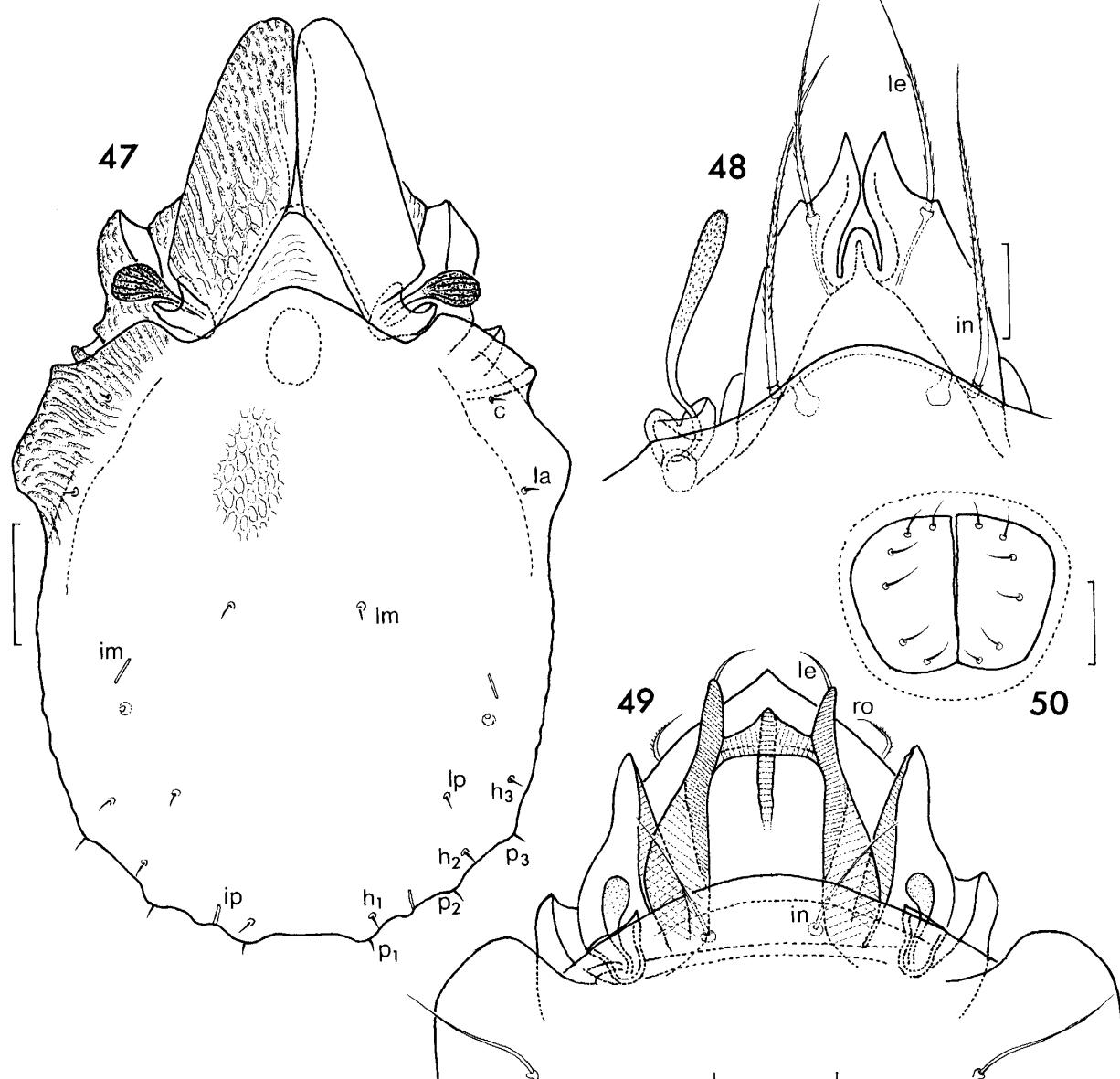
*Measurement.* Body length 345–375  $\mu\text{m}$ , width 200–205  $\mu\text{m}$ .

*Remarks.* The species is originally described from St. Lucia Island of the Antilles Islands. The

founding of the species from Japan was, therefore, unexpected, but the shape of humeral projections, small knobs bearing notogastral setae of *ps*-series and reticulate surface structure of notogaster designate the Japanese specimens as *E. undulatus*.

*Specimens examined.* Two specimens: Tonaki Island, the Okinawa Islands, 20-IV-2006, J. Aoki. From soil and roots of grasses growing on limestone cliff near the shore.

*Distribution.* The Antilles Islands and Japan (new record).



Figs. 47. *Eremaeozetes undulatus* Mahunka, 1985. Dorsal view of body. Fig. 48. *Lamellobates orientalis* Csiszár, 1961. Anterior part of body. Figs. 49–50. *Mycobates tricostatus* sp. nov. 49: Anterior part of body. 50: Genital aperture. Scale bars: 50  $\mu\text{m}$  in Figs. 47 and 49, 20  $\mu\text{m}$  in Figs. 48 and 50.

### *Lamellobates orientalis* Csiszár, 1961

(Fig. 48)

*Lamellobates orientalis* Csiszár, 1961: 354, fig. 24.

*Measurement.* Body length 275–280  $\mu\text{m}$ , width 195–200  $\mu\text{m}$ .

The shape of lamellar cusps is so peculiar, that the species is easily distinguishable from the congeners. Median cusps are strongly developed like sharp knives and warped outward. A prominent median process is found between cusps.

*Specimens examined.* Three specimens: Oto-mi, Iriomote Island, the Yaeyama Islands, 25-VI-2005, J. Aoki.

*Distribution.* Java and Japan (new record).

***Mycobates tricostatus* sp. nov.**

(Figs. 49–50)

*Measurement.* Body length 325–370 µm, width 210–230 µm.

Prodorsum. Rostrum pointed, but not so sharply (Fig. 49). Rostral setae finely barbed. Lamella thick, gradually narrowed anteriorly; lamellar cusp curved downward apically, with a fine lamellar seta. A broad and conspicuous translamella triangular on its anterior margin with a median projection extending toward posterior direction and forming a longitudinal median ridge. Interlamellar setae fine and long, longer than their mutual distance. Sensillus sigmoid, with a fairly thick peduncle and a clavate head bending medially. Bothridia and insertion pores of interlamellar setae completely concealed under anterior notogastral tectum.

Notogaster. Notogaster with strongly arched anterior margin and anteriorly projecting pteromorphae. Ten pairs of notogastral setae fine, long and whip-like.

Anogenital region. Genital plates with 6 pairs of fine setae inserted in circular arrangement (Fig. 50). Anal aperture a little wider than long, with 2 pairs of setae widely separated. Anterior-most adanal setae ( $ad_3$ ) situated in level with, or slightly anterior to, anterior anal setae ( $an_2$ ).

*Type series.* Holotype (NSMT-Ac 11863) and 1 paratype (NSMT-Ac 11864): Kohanano-Egou, Yaku Island, the Ohsumi Islands, 30-VII-1981, H. Harada—1 paratype (NSMT-Ac 11865): Mt. Kuromi-dake, Yaku Island, the Ohsumi Islands, 30-VII-1981, H. Harada.

*Remarks.* The new species is easily separable from the known congeners by the peculiar translamella with a triangular projection accompanied by a strong median ridge.

***Mochlozetes ryukyuensis* sp. nov.**

(Figs. 51–55)

*Measurement.* Body length 1040–1250 µm, width 880–1100 µm.

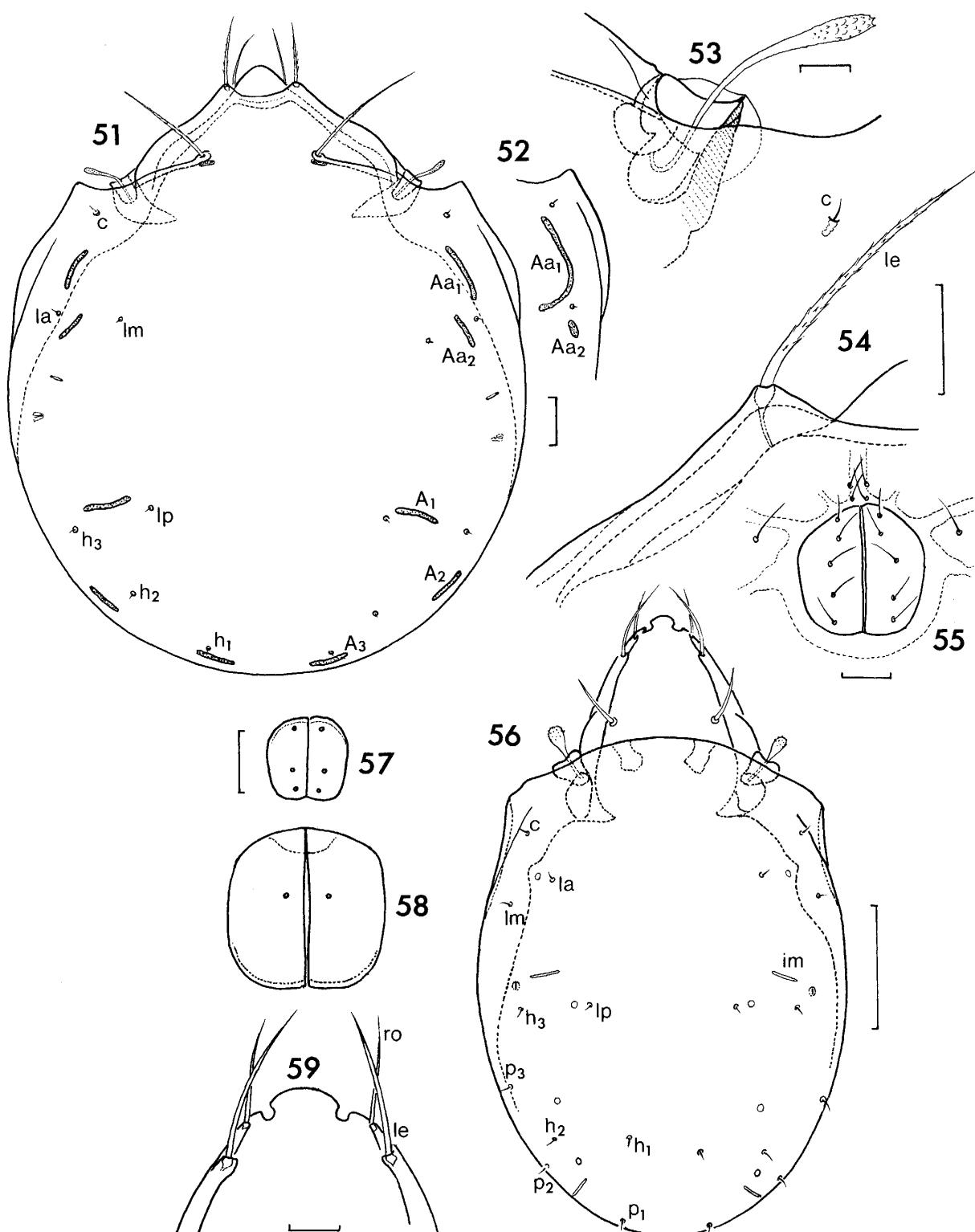
Prodorsum. Rostrum rounded. Rostral and lamellar setae thin, very weakly barbed (Fig. 54); interlamellar setae thin and nearly glabrous;  $ro/ro-ro=1.0$ ,  $le/le-le=1.2$ ,  $in/in-in=1.4$ ;  $ro:le:in=1:1.3:3.0$ . Translamella strongly developed, anterior margin smoothly concave and bending. Sensillus short and thin, with an inconspicuously thickened head of rough surface (Fig. 53). Dorsosugal suture interrupted medially.

Notogaster. Outline of notogaster almost circular, of equal length and width. Pteromorphae distinctly developed, projecting anteriorly and laterally beyond outline of notogaster. Five pairs of ribbon-shaped areae porosae;  $Aa$  divided into two parts ( $Aa_1$  and  $Aa_2$ );  $Aa_2$  1/2–2/3 of  $Aa_1$  in length (Fig. 51),  $Aa$  sometimes small and oval (Fig. 52);  $A_1$  aligned almost transversely, a little shorter than, or nearly equal to,  $Aa_1$ , and somewhat longer than  $A_2$  and  $A_3$ . Ten pairs of notogastral setae very minute; seta  $la$  located between  $Aa_1$  and  $Aa_2$ , seta  $ip$  medial to  $A_1$ ,  $h_1$  close and anterior to  $A_3$ .

Anogenital region. Genital plates with 5 pairs of thin and long setae;  $g_1$  and  $g_2$  inserted closer to median margin of the plates than the remaining setae are (Fig. 55). Anal plates with 2 pairs of setae;  $an_1$  a little closer to median margin than  $an_2$  is. Three pairs of anadal setae long and thin;  $ad_1$  and  $ad_2$  located posterior to anal opening  $ad_3$  nearly in level with anterior margin of anal opening. Adanal fissures close and parallel to lateral margin of opening.

*Type series.* Holotype (NSMT-Ac 11832): Southwest slope of Mt. Yokodake, Kuchinoshima Island, the Tokara Islands, 19-III-1987, J. Aoki—1 paratype (NSMT-Ac 11833): Mitera Shrine, Akuseki Island, the Tokara Islands, 17-III-1987, J. Aoki—1 paratype (NSMT-Ac 12013): At the foot of Mt. Omoto, Ishigaki Island, the Yaeyama Islands, 5-X-1978, J. Aoki.

*Remarks.* The new species differs from the



Figs. 51–55. *Mochlozetes ryukyuensis* sp. nov. 51: Dorsal view of body. 52: A variation of areae porosae Aa. 53: Bothridium and sensillus. 54: Lamella and lamellar seta (left side). 55: Genital aperture. Figs. 56–59. *Birobates nasutus* sp. nov. 56: Dorsal view of body. 57: Genital aperture. 58: Anal aperture. 59: Rostral part. Scale bars: 100 µm in Figs. 51 and 52, 50 µm in Figs. 54–56, 20 µm in Figs. 53, 57–59.

known congeners by (1) thick and bending translamella, (2) marked pteromorphae with angulate anterior margin, (3) five pairs of areae porosae usually not so largely different in size.

***Birobates nasutus* sp. nov.**

(Figs. 56–59)

**Measurement.** Body length 240  $\mu\text{m}$ , width 140–150  $\mu\text{m}$ .

**Prodorsum.** Rostrum incised on each side, producing a median truncate snout (Fig. 59). Rostral seta inserted at the tip of a lateral ridge. Lamellar seta longer than rostral seta, inserted at lamellar tip. Interlamellar seta 1.3–1.4 times as long as lamellar seta. Bothridium partly protruding from anterior margin of notogaster. Sensillus directed anterolaterally, bearing a short peduncle and a rounded head with very fine barbs (Fig. 56).

**Notogaster.** Notogaster 1.3–1.4 times as long as wide, widest at mid-distance along its length; anterior margin gently and smoothly arched. Ten pairs of notogastral setae fine and minute. Four pairs of sacci small and rounded. Lyrifissures *im* and *ip* long and prominent.

**Ventral side.** Apodemata *apo*<sub>2</sub> short, arched, connected medially with indistinct sternal ridge; *apo*.*sj* long, aligned obliquely, connected medially with pre-genital thickening; *apo*<sub>3</sub> short, aligned transversely, interrupted medially. Genital plates with 3 pairs of setae; *g*<sub>2</sub> inserted closer to *g*<sub>3</sub> than to *g*<sub>1</sub> (Fig. 57). Anal plates with only one pair of setae, situated in level a little anterior to mid-distance along length of anal plates (Fig. 58). Three pairs of adanal setae: *ad*<sub>1</sub> and *ad*<sub>2</sub> located rather close to each other near posterolateral corner of anal opening; *ad*<sub>3</sub> situated far anteriorly. Adanal fissures *iad* short, indistinct, situated close to lateroanterior margin of anal opening.

**Type series.** Holotype (NSMT-Ac 11846) and 17 paratypes (NSMT-Ac 11847–11850): Shiratani Unsui Valley, Yaku Island, the Ohsumi Islands, 8-X-2003, J. Aoki. From moss (*Plagiochila pulcherrima* Horik.) growing on a tree trunk.

**Remarks.** Seven species of the genus *Birobates* have hitherto been known. They are separated

into two groups: the group 1 with only one pair of anal setae (*Birobates reductus* Balogh, 1970, *B. makinicus* Corpuz-Raros, 1979 and *B. acutus* Hammer, 1971) and the group 2 with two pairs of anal setae (*B. fenicheli* Balogh, 1972, *B. payatosensillus* Corpuz-Raros, 1979, *B. rotundus* Hammer, 1971 and *B. latus* Hammer, 1971). The new species belongs to the group 1, but it is distinguishable from the three known members by the rostrum with a distinct median snout, slender body and somewhat angulate anterior notogastral margin, and *B. makinicus* has more strongly swollen head of sensilli and shorter lyrifissures *im*.

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